Shear Force Procedures for Meat Tenderness Measurement

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We have systematically attempted to determine the most accurate and repeatable method to measure shear force and sensory tenderness of cooked meat. A major factor affecting the repeatability of shear force and sensory tenderness is the cooking method used. The most repeatable method we have tested is belt grill cookery. Cooking one-inch thick steaks and chops for a constant amount of time with a belt grill is much more repeatable (R = .85 vs .64) than cooking to a constant endpoint temperature using open-hearth electric broilers. Longissimus shear force can be determined more easily and with greater precision (R = .89 vs .85) using slice shear force as compared with Warner-Bratzler shear force. Therefore, shear force can be determined most precisely combining belt grill cookery with slice shear force.

Belt Grill Cookery

1. If meat is to be aged before evaluation, cuts should be vacuum packaged and held at 0 to 3°C during transportation and storage.

2. To achieve the most accurate cookery with a belt grill, steak thickness must be precisely controlled. The easiest way to ensure uniform steak thickness is to freeze (-20°C) a muscle or muscle section at the end of the aging period and subsequently cut one-inch thick steaks from the frozen sections using a band saw. Muscles or muscle sections should be frozen individually without stacking (rather than after boxing) to ensure uniform, rapid freezing.

3. Internal temperature of the sample at the initiation of cooking can affect tenderness, thus, this variable must be standardized. Frozen samples should be thawed at 2 to 5°C until an internal temperature of 2 to 5°C is reached. For 1 inch thick steaks, the time frame is approximately 24 to 36 hours (thawing time depends largely on the ratio of frozen meat to refrigerator/cooler size). During thawing, avoid steak overlap and stacking to improve the consistency of the thawing process. Internal temperature of steaks should be verified prior to cooking.

4. Steaks should be cooked to a final internal temperature of 71°C using a belt grill (TBG-60 Magigrill, MagiKitch'n Inc., Quakertown, PA). The belt grill should be operated as follows: preheat = 149°C, top heat = 163°C, bottom heat = 163°C, height of gap = 2.16 cm, and cook time = 5.5 min. (These settings should be tested toensure 71°C end point is reached on average).

5. After the steaks exit the belt grill, they should be held at room temperature for post-cooking temperature rise to be completed. During post-cooking rise, a needle thermocouple should be inserted into the geometric center of the steak and post-cooking rise monitored with a hand-held thermometer (Cole-Parmer, Vernon Hills, IL). The maximum temperature, which occurs about 2 min after the steak exits the belt grill, should be recorded as the final cooked internal temperature.

Longissimus Slice Shear Force Measurement

Slice shear force has been developed and validated only for longissimus. Until slice shear force procedures are developed for other muscles, Warner-Bratzler shear force should be used for objectively evaluating tenderness in those muscles.

1. Immediately after cooking, a 1-cm-thick, 5-cm-long slice should be removed from the lateral end of each steak parallel to the muscle fibers.

    a) A cut should be made across the width of the longissimus at a point about 2 cm from the lateral end of the muscle.

    b) Using a sample sizer, a second cut should be made across the longissimus parallel to the first cut at a distance 5 cm from the first cut.

    c) Using a knife that consists of two parallel blades spaced 1 cm apart, two parallel cuts should be simultaneously made through the length of the 5 cm long steak portion at a 45° angle to the long axis of the longissimus and parallel to the muscle fibers.

2. The slice should be sheared perpendicular to the muscle fibers using an electronic testing machine equipped with a flat, blunt-end blade (thickness 1.016 mm, cutting edge beveled to a half-round, the spacers providing the gap for the cutting blade to slide through should be 1.245 mm thick). The crosshead speed should be set at 500 mm / min.

Open-Hearth Electric Broiler Cookery

1. If meat is to be aged before evaluation, cuts should be vacuum packaged and held at 0 to 3°C during transportation and storage.

2. To achieve the most accurate cookery with an open-hearth electric broiler, steak thickness should be precisely controlled. The easiest way to ensure uniform steak thickness is to freeze (-20°C) a muscle or muscle section at the end of the aging period and subsequently cut one-inch thick steaks from the frozen sections using a band saw. Muscles or muscle sections should be frozen individually without stacking (rather than after boxing) to ensure uniform, rapid freezing. If steaks are hand cut, care should be taken to ensure uniform steak thickness and steaks should be vacuum-packaged and frozen individually without stacking (rather than after boxing) to ensure uniform, rapid freezing.

3. Internal temperature of the sample at the initiation of cooking can affect tenderness, thus, this variable must be standardized. Frozen samples should be thawed at 2 to 5°C until an internal temperature of 2 to 5°C is reached. For 1 inch thick steaks, the time frame is approximately 24 to 36 hours (thawing time depends largely on the ratio of frozen meat to refrigerator/cooler size). During thawing, avoid steak overlap and stacking to improve the consistency of the thawing process. Internal temperature of steaks should be verified prior to cooking.

4. Minimize time steaks are out of the refrigerator before cooking for inserting thermocouple wire. See AMSA (1995) for details on thermocouple wire insertion.

5. Samples should be cooked to an internal temperature of 40°C, flipped, and cooked to a final internal temperature of 71°C.

Warner-Bratzler Shear Force Measurement

1. After cooking, steaks should be chilled overnight at 2 to 5°C before coring.

2. Round cores should be 1.27 cm in diameter and removed parallel to the longitudinal orientation of the muscle fibers so that the shearing action is perpendicular to the longitudinal orientation of the muscle fibers. Cores can be obtained using a hand-held coring device or an automated coring device. Coring devices must be in good condition and sharp or the core diameters will vary and result in increased variation in shear values.

3. A minimum of six and maximum of eight cores should be obtained from each steak. Cores that are not uniform in diameter, have obvious connective tissue defects or otherwise would not be representative of the sample should be discarded. Cores should be kept refrigerated (2 to 5°C) until they are sheared. All values obtained should be used for mean calculation, unless visual observation indicates some reason that value should be discarded (e.g., a piece of connective tissue).

4. Shear each core once in the center to avoid the hardening that occurs toward the outside of the sample.

5. Shearing must be done by using a Warner-Bratzler shear machine or an automated testing machine with a WBS attachment and crosshead speed set at 200 mm/min. Warner-Bratzler shear blade specifications include: 1) blade thickness 1.016 mm, 2) vee-shaped (60 degree angle) cutting blade, 3) cutting edge beveled to a half-round, 4) corner of the vee should be rounded to a quarter-round of a 2.363 mm diameter circle, 5) the spacers providing the gap for the cutting blade to slide through should be 1.245 mm thick.

6. Shear tests conducted with modifications to these specifications (e.g., square holes, square meat samples, straight cutting blade, or blade edge not properly beveled) should not be referred to as Warner-Bratzler shear force.

For additional information see:

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